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Original article

Medial acetabular wall breach in total hip arthroplasty – is full-weight-bearing possible?



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ARTICLE INFO

Article history:
 Received 26 January 2018
 Accepted 26 April 2018

Keywords:
 Acetabular component
 Bone defect
 Medial breach
 Partial weight-bearing
 Total hip arthroplasty
 Total hip replacement

ABSTRACT

Background: A breach of the medial acetabular wall is a phenomenon seen frequently due to over-reaming during total hip arthroplasty (THA). The consequences of this issue are not fully understood particularly in cementless THA. A retrospective study was performed to answer whether: immediate postoperative full-weight-bearing in the presence of a medial acetabular wall breach after THA results in more short-term revisions of the acetabular component, and increases the risk for migration of the acetabular component?
Hypothesis: Immediate full-weight-bearing in the presence of a medial breach is not associated with an increased likelihood for acetabular-related revision surgery or migration of the cup.

Patients and methods: In this retrospective cohort study, consecutive patients ($n = 95$; mean age 68 ± 13 years; 67 female) who underwent THA with an uncemented acetabular component were identified and a retrospective chart review was performed (follow-up 23 ± 17 months, range 6 to 79 months). The presence of a postoperative radiographic medial acetabular breach was documented and the need for revision surgery and the rate of acetabular component migration were assessed during follow-up.

Results: Some extent of radiographic medial acetabular wall breach was seen in 26/95 patients (27%). With regard to the primary outcome, 2/95 patients (2%) required revision surgery during follow-up. All revision surgeries occurred in the group without a medial breach ($p = 0.280$) for causes related to the femoral or the head components. Persistent pain was present in 1/26 patients (3.8%) in the medial breach group and 8/69 patients in the control group (11.6%; $p = 0.436$). In the radiographic follow-up ($n = 81$), there was no significant difference between the control group and the medial breach group with regard to cup migration (Δ ilio-ischial overlap [distance between the ilio-ischial line and a parallel line tangential to the acetabular cup on AP views]: -0.5 ± 0.9 mm [range, -2.9 to 0.8] vs. -0.3 ± 1.7 mm [range, -1.9 to 2.2], Δ overlap tangent [defined as the distance between the two crossings of ilio-ischial line and the acetabular component on AP views]: -2.2 ± 6.1 mm [range, -21.4 to 0.0] vs. 0.4 ± 6.9 mm [range, -6.2 to 17.6]). Similarly, according to variation in the ilio-ischial overlap distance between postoperative and follow-up on pelvic AP views, 0/56 hips (0%) had cup migration ≥ 5 mm in the control group versus 1/25 (4%) in the medial breach cohort ($p = 0.3$).

Discussion: In this retrospective observation of patients with immediate postoperative full-weight-bearing after THA, a radiographic breach of the medial acetabular wall was not associated with an increased risk for short-term revision surgery or radiographic migration at follow-up. According to the findings of this study and in the light of previous biomechanical studies, there is no clear evidence for post-operative partial weight-bearing in case of a medial breach as far as the surgeon feels that the acetabular component is stable.

Level of Evidence: IV, Retrospective cohort study.

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1. Introduction

Reaming of the acetabulum is one of the key steps in THA [1,2]. Over-reaming or reaming to medially can cause a bone defect in the medial wall of the acetabulum. It remains unclear, however, whether this determines a higher risk of implant dislocation or

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periprosthetic fractures [3–5]. Too medial positioning of the acetabular cup with a medial breach may lead to a secondary migration of the implant, implant impingement, pain and sometimes revision surgery because of a possible weakness of the construct due to excessive removal of medial acetabular wall.

Usually, patients can be allowed full-weight-bearing after THA [6,7], but recent biomechanical studies concluded that a medial wall breach of 2 cm is associated with 26% decrease in load to failure of acetabular components in human cadavers [8] and a lower load to failure in canine acetabula [9]. However, the authors concluded that this difference was not clinically relevant since the applied breaking forces exceeded the normal physiologic loads in the dog during the gait. Neither of these findings has been confirmed in vivo.

What remains unclear is the relevance of a medial defect and how it should influence our intra-operative and postoperative strategy, since the majority of the stability of the acetabular component is determined by contact with the acetabular rim [10]. There is little evidence regarding the best surgical solution in case of a medial wall breach during hip total arthroplasty. Salvati et al. [11] stressed the importance of an intact acetabular medial wall and, in case of a defect, suggested immediate support by intra-operative bone grafting. Other solutions are acetabular revision cages and acetabular line-to-line cups with screw fixation and many surgeons recommend postoperative partial weight-bearing. At the authors' institution, no intra-operative repair of the defect nor a change of the postoperative rehabilitation protocol with immediate full-weight-bearing is performed as long as the cup intra-operatively shows to be stable under direct manipulation. Particularly, it remains unclear whether protected weight-bearing is really needed in patients with a medial breach after THA. Therefore we performed a retrospective study to investigate whether immediate postoperative full-weight-bearing in the presence of a medial acetabular wall breach after THA increases the risks for complications related to the acetabular component. The questions to be answered by this study were:

Does immediate postoperative full-weight-bearing bearing in the presence of a medial acetabular wall breach after THA:

- result in more short-term revisions of the acetabular component?
- Increase the risk for migration of the acetabular component?

Our hypothesis was that there is no increased likelihood for acetabular-related revision or migration of the cup with immediate full-weight-bearing in the presence of a medial breach.

2. Materials and methods

2.1. Patients

This retrospective cohort study was carried out in accordance with the local institutional ethics committee's terms of reference (Kantonale Ethikkommission Zürich, Switzerland. KEK-ZH-Nr. 2014-0557). Consecutive patients aged more than 18 years who underwent THA at a University Trauma Center between 10/2008 and 04/2016 were identified by a search of the hospital's database and a retrospective chart review was performed ($n = 287$). Patients with a cemented acetabular component ($n = 101$), a preoperative *Coxa protrusio* ($n = 5$) [12], or a follow-up of less than 6 months ($n = 81$), and patients who underwent THA through an approach other than an anterior approach ($n = 5$) were excluded (Fig. 1). Final analysis was performed in 95 patients (mean age 68 ± 13 years, range 39 to 92 years; 67 female), baseline characteristics are provided in Table 1. The mean follow-up for all patients was 23 months \pm 17 months (range, 6 to 79 months).

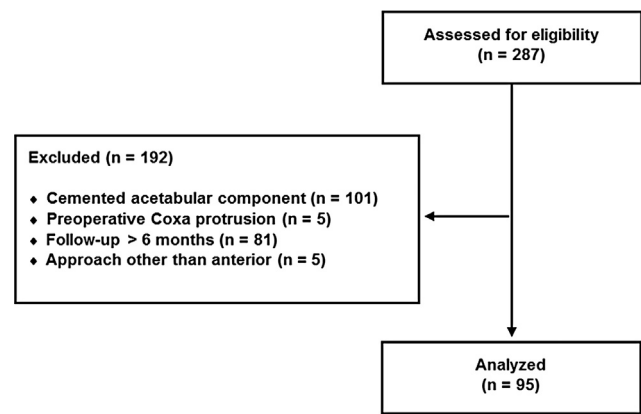


Fig. 1. Patient selection flowchart.

Table 1

Baseline characteristics.

	No breach	Medial breach	p
n	69	26	
Follow-up (months)	24 \pm 18 (6 to 71)	21 \pm 14 (6 to 65)	0.357 ^a
Age (years)	67 \pm 13 (39 to 86)	70 \pm 13 (42 to 92)	0.211 ^a
Gender (female)	42 (60.9%)	25 (96.2%)	0.001 ^b
Coxa profunda	23 (33.3%)	15 (57.7%)	0.031 ^b

^a t-test.

^b Chi² test. Data is presented as mean \pm standard deviation (range) or frequencies (percentage).

2.2. Methods

The indication for THA was a femoral neck fracture in 73/95 patients (76.8%, 69 primary and 4 after internal failed fixation), primary or secondary (after acetabular fractures) osteoarthritis of the hip in 19 patients, and idiopathic femoral head necrosis in three patients.

All patients received the same acetabular component (Versafit CC Trio, Medacta International SA, Switzerland) and were operated through a minimal-invasive anterior (modified Smith-Petersen) approach by one of three board-certified orthopaedic surgeons trained with this approach. The used acetabular component with an elliptical shape and 0.7 mm diameter circular retaining splines had a titanium and hydroxyapatite coating. Cup size was chosen 4 mm larger than the femoral head. The mean cup size in the medial breach group was 51 ± 3 mm (range, 48 to 58 mm) and 52 ± 3 mm (range, 48 to 60 mm) without medial breach. After impaction, cup anchorage was tested by pulling with a strong forceps. Reaming was performed under fluoroscopic imaging and it was tried to ream medially until touching Kohler's tear drop and cranially until bleeding from the subchondral bone was seen [2,13]. No screws were used for additional fixation of the acetabular cup. The femoral component (Quadra, Medacta International SA, Switzerland) was cemented in patients aged over 65 years (59/95 patients, 62.1%), otherwise cementless stems were used if sufficient bone stock was present [14]. Femoral head sizes of 28 mm and 32 mm were used. Postoperatively, all patients were allowed to immediately full-weight-bear but were given crutches for balance and gait stability.

2.3. Methods of assessment

The primary endpoint was the need for revision surgery of the acetabular component, excluding exchange of the polyethylene inlay. In addition, the presence of persisting pain at latest follow-up

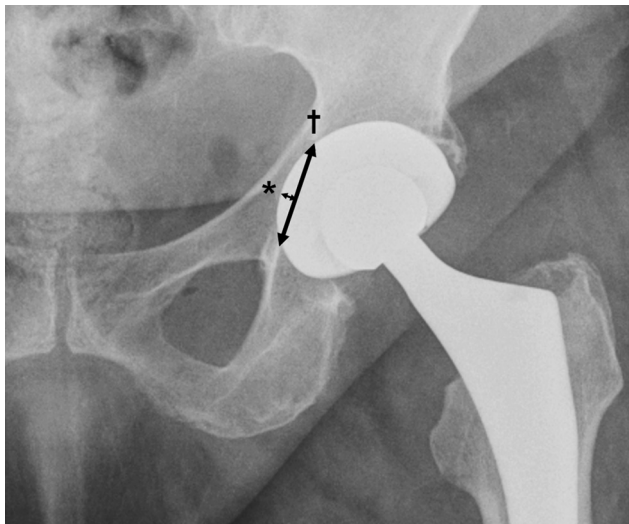


Fig. 2. Radiographic measurements of the medial acetabular breach on AP pelvis views: ilio-ischial overlap and overlap length. * The ilio-ischial overlap was defined as the distance between the ilio-ischial line and a parallel line tangential to the acetabular cup on AP views of the whole pelvis. † The length of overlap tangent was defined as the distance between the two crossings of ilio-ischial line and the acetabular component on AP views of the whole pelvis.

was documented. This was obtained through a retrospective chart review.

Secondary endpoint was radiographic migration. Conventional digitalized AP radiographs of the whole pelvis were taken by a MULTIX/Optitop 150/40/80 tube (Siemens, Munich, Germany; 71–90 kV, 25–40 mA). All radiographs were taken in a standardized fashion with a film-focus distance of 115 cm. Radiographic measurements were performed using the caliper tool of institutional imaging software (AGFA™ Impax viewer; AGFA, Mortsel, Belgium).

The presence of a *Coxa profunda* configuration on preoperative radiographs and of a medial acetabular wall breach on immediate postoperative radiographs was documented. Medial wall breach was defined as intersection of the prosthetic cup with the ilio-ischial line. A *C. profunda* was defined as the acetabular fossa being medial to the ilio-ischial line on the pelvis radiograph [15].

Three parameters were measured in order to quantify medial breach and medial protrusion on immediate postoperative radiographs of the whole pelvis:

- the ilio-ischial overlap, that was defined as the distance between the ilio-ischial line and a parallel line tangential to the acetabular cup. (Fig. 2). In case of no medial breach this value was negative and represented the minimal distance between the cup and the ilio-ischial line;
- the length of overlap tangent, that was defined as the distance between the two crossings of ilio-ischial line and the acetabular component (Fig. 2). In case of no medial breach, this distance was zero;
- the ilio-pectineal distance, that was defined as the minimal distance between the ilio-pectineal line and the acetabular component (Fig. 3).

These measurements were repeated on follow-up radiographs at latest follow-up and compared to the postoperative measurement in order to assess potential migration. The difference between both measurements was calculated for each patient and reported as Delta (Δ) in Table 2. Based on previous radiometric studies around the hip, a change in ilio-ischial overlap of more than 3 mm was considered clinically relevant [16].

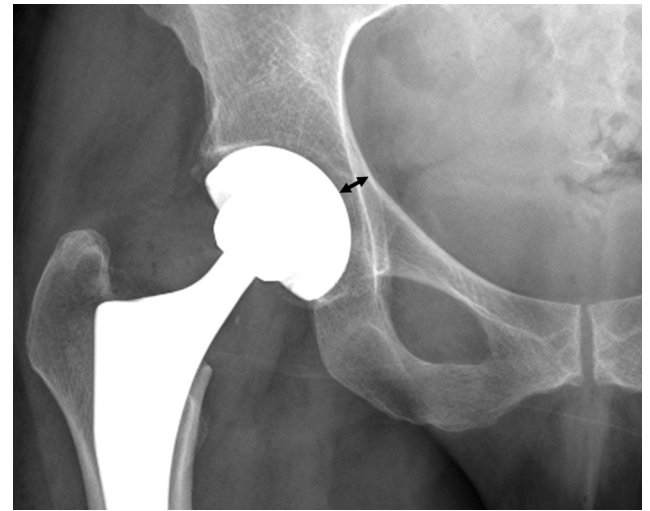


Fig. 3. Radiographic measurements of the medial acetabular breach: ilio-pectineal distance. The ilio-pectineal distance was defined as the minimal distance between the ilio-pectineal line the acetabular component on AP views of the whole pelvis.

Table 2

Relationship between gender and preoperative *C. profunda*.

	Normal hip	<i>Coxa profunda</i>	Total	<i>p</i>
<i>n</i>	57	38		0.017
Female	35 (52.2%)	32 (47.8%)	67	
Male	22 (78.6%)	6 (21.4%)	28	

Data is presented as frequencies (percentage). Chi² test (gender vs. *Coxa profunda*): *p* = 0.017.

Initial postoperative radiographs were compared with the most current, correctly orientated film [17] that was archived in our patient database. Thirteen patients had to be excluded for the radiographic follow-up because the initial postoperative radiograph was derotated or because there was no similarly orientated follow-up radiograph.

All measurements were performed three times by the same author (ST) and the mean was calculated. Intra class correlation coefficients (two-way mixed effects, consistency) were: postoperative ilio-ischial overlap: 1.0 (95% CI: 1.0 to 1.0; *p* < 0.001), postoperative overlap tangent: 0.997 (95% CI: 0.995 to 0.998; *p* < 0.001), postoperative ilio-pectineal distance: 0.939 (95% CI: 0.911 to 0.960; *p* < 0.001), follow-up ilio-ischial overlap: 1.0 (95% CI: 1.0 to 1.0; *p* < 0.001), follow-up overlap tangent: 1.0 (95% CI: 0.999 to 1.0; *p* < 0.001), follow-up ilio-pectineal distance: 1.0 (95% CI: 0.999 to 1.0; *p* < 0.001).

2.4. Statistical analysis

Primary endpoint was the need for revision surgery of the acetabular component. Prior to data acquisition, a sample size calculation was performed with a desired two-tailed Type I error of 0.05 and a power of 0.90. Based on literature data, we expected a 2-year baseline risk for acetabular component revision of 1% [18]. The expected proportion of patients with a postoperative medial breach due to over-reaming was 5%. This revealed a minimum sample size of 39 patients for this study [19].

Further statistical analysis was done by the use of SPSS for windows 23.0 (SPSS, Chicago, Illinois, USA). Data are presented as frequencies (*n*) and means with the standard deviation (SD). To assess differences in means between the two groups, an independent-samples *t*-test was used for the normally distributed continuous data and a Chi² test for categorical data. Missing data

Table 3
Radiographic follow-up.

	No breach	Medial breach	<i>p</i>
<i>n</i>	56	25	
Δ ilio-ischial overlap, (mm)	−0.5 ± 0.9 (−2.9 to 0.8, 0 hip, 0 hip)	−0.3 ± 1.7 (−1.9 to 2.2, 0 hip, 1 hip)	0.548 ^a
Δ overlap tangent, (mm)	2.2 ± 6.1 (0.0 to 21.4, 1 hip, 8 hips)	0.4 ± 6.9 (−6.2 to 17.6, 6 hips, 9 hips)	0.092 ^a
Δ ilio-pectineal distance, (mm)	−0.7 ± 1.5 (−2.3 to 8.1, 1 hip, 1 hip)	0.4 ± 0.9 (−1.0 to 2.4, 0 hip, 0 hip)	0.424 ^a

Data is presented as mean ± standard deviation (range, number of patients with a Δ ≥ 3 mm and <5 mm, number of patients with a Δ ≥ 5 mm).

^a *t*-test. Δ= DELTA/difference between absolute measures on the postoperative and the follow-up radiograph. Thirteen patients had to be excluded for the radiographic follow-up because the initial postoperative radiograph was derotated or because there was no similarly orientated follow-up radiograph.

were reported as such for each outcome parameter. The level of statistical significance was set at $p < 0.05$.

3. Results

Some extent of radiographic medial acetabular wall breach was seen in 26/95 patients (27%).

These patients showed a mean postoperative radiographic ilio-ischial overlap of the acetabular component of 4.1 ± 2.6 mm (range, 0.7 to 10.2 mm), a mean overlap tangent length of 27.4 ± 8.0 mm (range, 13.3 to 44.5 mm), and a distance between acetabular component and ilio-pectineal line of 5.9 ± 3.4 mm (range, 0.5 to 11.0). Patients without a medial wall breach showed a mean postoperative radiographic ilio-ischial overlap of the cup of -2.4 ± 2.4 mm (range, −9.2 to 0.0 mm) and a distance between acetabular component and ilio-pectineal line of 10.1 ± 3.8 mm (range, 2.0 to 16.5), as there was no ilio-ischial overlap of the cup in the no breach group, there was no tangent to measure.

A postoperative medial acetabular breach was more frequently found in women (χ^2 , $p = 0.001$) and patients with a preoperative *Coxa profunda* (χ^2 , $p = 0.031$, Table 2).

With regard to the primary outcome, 2/95 patients (2.1%) required revision surgery or intervention during follow-up. All revision surgeries occurred in the group without a medial breach (χ^2 , $p = 0.280$). These comprised one head change to a larger head due to recurrent dislocation (at 2.5 months after index surgery), and one change of the femoral component due to an early shaft subsidence after a fall (at 3 weeks after index surgery). One additional patient (1/95, 1.1%) required closed reduction of an early dislocation (at 21 days after index surgery) with the further follow-up being uneventful (in total the rate of dislocation was 2/95 (2.1%) one requiring bearing component exchange and one treated by reduction). There was no revision surgery for the acetabular cup. Persistent pain was present in 1/26 patients (3.8%) in the medial breach group and 8/69 patients in the control group (11.6%) (Fisher's Exact, $p = 0.436$). Seven of 9 patients (77.7%) with persistent pain had uncemented femoral components.

In the radiographic follow-up ($n = 81$), most patients showed subtle changes of the three radiographic parameters in terms of migration but the amount of these changes were not different between the two groups (Table 3). With regard to the ilio-ischial overlap distance between postoperative and follow-up on pelvic AP views, 0/56 hips (0%) had cup migration ≥ 5 mm in the control group versus 1/25 (4%) in the medial breach cohort ($p = 0.3$).

4. Discussion

While component oversizing and osteoporosis are well known risk factors for acetabular fractures there is still debate whether a medial wall defect could trigger postoperative migration of the acetabular cup or the occurrence of periprosthetic acetabular fractures. The aim of this study was to investigate the relation between medial acetabular wall breach and complications related to the

acetabular component after a total hip arthroplasty in a cohort that was allowed immediate full-weight-bearing. Medial breach was intent as the protrusion of the acetabular component beyond the Kohler's line. In this cohort, there was radiographic evidence of medial breach of the acetabular cup in 1/4 of the patients, which is a relevant finding. However, a radiographic medial breach was not found to be correlated with an increased risk for secondary migration, dislocation, fractures or pain. None of the revision surgeries that we performed occurred in the study group and all were limited to the shaft component.

This is consistent with the findings of the aforementioned biomechanical studies that showed failure of acetabular components implanted in cadaver pelvises with a medial breach only with loads beyond physiological thresholds [8–10]. It is known, that the hip contact forces in an acetabulum of a 75 kg – individual range from 1543 N to 2116 N during routine activities [20]. In their biomechanical cadaver study, Martin et al. [8] reported fractures of the acetabulum after THA with loads of mean 4221 N in a group with a 2 cm medial defect. Hence, there is a great margin of safety between routine in vivo forces and the point of failure. However, it was also shown that the peak contact forces may raise to 3600 N in a patient with disturbed gait patterns [21] and up to 5300 N–6400 N during stumbling [20]. These values may of course put the acetabular wall in danger and could lead to a fracture. Walking with crutches may avoid the frequency of stumbling in these patients and thereby limit the risk for peak forces acting on the acetabular component – whether the patient is allowed to fully weight-bear or not. In fact, it is known from complex primary and hip revision surgery that intentionally breaching the medial wall by using the “medial protrusion technique” is not associated with increased complications related to the acetabular component [22].

The radiographic analysis of the secondary outcome migration was conducted on plain x-rays, limiting it to a bidimensional view with the related projection artefacts. This may lower the accuracy of detecting a defect of the lamina quadrilateral, meaning that some of the patients where a medial breach was noticed, may not have true bone defects and could be false positive cases. This is supported by the high rate of medial breach that we found postoperative. However the interruption of the Kohler's Line in pelvis antero-posterior x-rays is widely accepted as the standard to define a radiological defect of the medial acetabular wall. Furthermore, a plain x-ray is usually the first and commonly the only imaging modality available prior and after surgery. In the light of the lack of a late migration in all the patients with an interruption of the ilio-ischial line, the potential inclusion of false positive cases does not affect the clinical relevance of our results.

According to the findings of this study and in the light of previous biomechanical studies, there is no clear evidence that there is a need to reconstruct an intra-operative acetabular medial wall breach during a primary THA as far as the surgeon feels that the acetabular component is stable under direct manipulation. This could be explained by the fact that the majority of the stability of the acetabular component is determined by the contact in the equatorial area. In the investigated cohort, all

patients with a medial breach were allowed to full-weight-bear and this did not result in an increased rate of acetabular-related complications.

The limitations of this study are inherent with its retrospective study design. A follow-up of 6 months may be considered short in THA. However, in case of diminished anchorage of the acetabular component due to a medial breach, a cup-related complication or migration will most likely occur within the first three months under immediate full-weight-bearing. There may be small alterations of the biomechanics of the hip due to the medialization that could affect the longevity of the implants. This would require a follow-up several years, however. Measuring migration of the acetabular in the context of a medial wall breach has not been described previously in the literature. The only well-validated techniques for radiometric around the hip joint deal with natural hips [16]. We tried to compensate for this by the use of three different measurement methods. All three techniques showed an excellent intra-observer reliability. However, the large ranges of the changes in overlap tangent length and ilio-pectineal distance (Table 3) indicate that overlap tangent length and ilio-pectineal distance seem vulnerable to even small rotational errors when obtaining the radiograph. In contrast, the ilio-ischial overlap technique showed a small variance of the delta-values and, hence, seems to be a reliable method. Radiological follow-up included conventional radiographs only. Hence, occult fractures may have been undetected. As this study was performed in an Orthopaedic Trauma Center, a femoral neck fracture was the reason for THA in the large majority in this study's population. Even though there was no data available on the bone mineral density of all patients, there is an increased likelihood of higher age and impaired bone quality in the investigated cohort when compared to the average THA patient. Consistent with this, women—having a higher risk for impaired bone quality by gender—were more likely to sustain a medial breach in our study. This may be a potential bias of this study but also indicates that there is no increased risk for acetabular cup-related complications with an intra-operative medial breach even in elderly patients with fragile bone. On the other hand, the impaired quality of bone may be an explanation for the rather high rate of revision surgery related to the femoral component (2.1%). The primary outcome, however, was not of radiographic nature. Radiographic migration may be an indirect indicator for later pain and complications. The endpoint that is truly relevant from a patient's perspective, though, is the need for revision surgery—especially in a cohort of mainly elderly patients as seen in this study. Elderly patients need to get mobilized with early full-weight-bearing as they often cannot follow partial weight-bearing directions. In this study, the acetabular component seemed not at risk for revision in the presence of a medial breach – even with immediate full-weight-bearing.

5. Conclusion

In this retrospective observation of cohort of patients with immediate postoperative full-weight-bearing after THA, a radiographic breach of the medial acetabular wall was not associated with an increased risk for revision surgery, pain or, radiographic migration at follow-up.

Disclosure of interest

Georg Osterhoff has given paid lectures for Medtronic and Stryker.

The other authors declare that they have no competing interest.

Funding

There was no external funding for this study.

Contribution

FM and ST performed radiographic measurements and the chart review and participated in drafting the manuscript, JS and CMLW helped with chart review and data analysis and revised the manuscript. HPS participated in designing the study and revised the manuscript. GO participated in designing the study, performed the analysis and wrote the first draft of the manuscript.

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